Conclusions: Performing patient-specific QA for VMAT plan by using MapCHECK with IMF tool shows the result of agreement between Eclipse plan and measurement comparable with using ArcCHECK 3D diode array.

EP-1175

The matter of IMRT plan QA using gamma pass rate

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Purpose/Objective: The purpose of this work is to determine the statistical correlation between 2D IMRT QA passing rates and several clinically relevant, anatomy-based dose errors for per patient IMRTQA.
Materials and Methods: Thirty patients which performed QA of the treatment plan of the VMAT(VARIAN MedicalSystems, USA) with prostate cancer in the past were examined. Each planned with 10 MV linear accelerators (Novalis-Tx; Brain LAB) using a commercial treatment planning system (ECLIPSE; VARIAN Medical Systems, USA) and VMAT. In this study was compared with 2D or volume gamma pass rate and Dose Volume Histogram (DVH), and absolute dose. 2D gamma pass rate analysis was measured by 2D pixel ion-chamber (MatriXX; IBA, Germany). Volume gamma pass rate and DVH were computed by COMPASS MatriXX systems(IBA, Germany). The dose response data measured by the MatriXX(IBA, Germany) was imported to the COMPASS MatriXX systems, and volume gamma and DVH were calculated. The COMPASS MatriXX systems can perform only dose calculation by using imported DICOM plan data and dose response. As for the absorbed dose was compared with 0.6ml Farmer type ion-chamber and COMPASS MatriXX systems. An absorbed dose was compared with mean dose of the same area volume as the area volume measured by ion-chamber of the IMRT phantom, and correlation was investigated.
Results: A variation of 2D gamma pass rate was larger than volume gamma. As a result of performing comparison of 2D gamma pass rate and DVH, absorbed dose error was less than 5% in DVH when 2D gamma pass rate was more than 95% of PTV. However,even if the rectum and bladder were more than 95% gamma pass rate, there was dose error more than 5% in 40% of all measured data. There were correlated with absolute dose measured by 0.6ml ion-chamber and computed by the COMPASS MatriXX systems ($p<0.01$).
Conclusions: Although IMRT Plan QA by means of 2D or volume gamma pass rate were suitable as objective rating of distribution, it was suggested that these were not suitable as clinical assessment of IMRT Plan.

EP-1176

Three years of VMAT patient quality assurance with the PTW seven29 ionization chamber array and Octavius phantom

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Purpose/Objective: The introduction of VMAT in clinical routine can be limited for the complexity and time needed in pre-treatment verification, decreasing the number of patients that could benefit. A fast and reliable dosimetric device is then required. Since 2009, over 400 patients have been treated with Volumetric modulated arc therapy (VMAT) at Fondazione di Ricerca e Cura 'Giovanni Paolo II' of Campobasso, Italy. In this study we present the three-years results of our patient specific QA program using the PTW seven29/Octavius system and our institutional guidelines for VMAT delivery.
Materials and Methods: From June 2009 to October 2012, 410 patients were treated with VMAT technique at our institution using Elekta linacs and Oncentra Masterplan TPS. Patients were divided in three groups: (1) 125 patients with high-modulated complex treatments for head-neck, rectal, endometrial and brain tumours, all treated with Simultaneous Integrated Boost strategy using two arcs; (2) 140 patients with prostate and vaginal tumours and (3) 145 patients undergone to radiosurgery or extracranial stereotactic techniques for bone, liver, lung, abdominal and pelvic metastasis, treated by one arc. The absolute doses were measured utilizing the PTW Seven29 ion-chamber array and the Octavius phantom. VMAT plans were recalculated on phantoms representing the Octavius geometry and density; for each arc the doses were measured both on coronal and sagittal planes, for a total of 1070 measurements. Agreement of measured and predicted doses were evaluated using gamma index set at 3%/3mm. Three scalar metrics were evaluated for each measurement: (a) percentage of points with gamma value less than one ($P_{\gamma<1}$), (b) mean gamma (γ_{mean}), and (c) maximum gamma (γ_{max}). Dose measurements at isocenter point were extracted by the seven29 central 0.125 cc ion chamber.
Results: $P_{\gamma<1}$, γ_{mean} and γ_{max} averaged over all treatment sites were 96.8% ± 3.0%, 0.37 ± 0.08 and 1.58 ± 0.70, respectively. For the patients in group (1), $P_{\gamma<1}$, γ_{mean} and γ_{max} were 95.7% ± 3.0%, 0.39 ± 0.08 and 1.90 ± 0.62, respectively. These values reached 98.2% ± 3.3%, 0.35 ± 0.09 and 1.13 ± 0.61 values in group (2) and 98.3% ± 2.3%, 0.31 ± 0.08 and 1.24 ± 0.70 values in group (3). Our local confidence limits for $P_{\gamma<1}$ were determined to be 9.1% over all treatment sites, and 10.2%, 8.1%, and 6.2%, for patients in group 1, 2 and 3, respectively. Mean values and SD of ion-chamber differences between isocenter measured and calculated doses were -0.4% ± 2.8%, -0.7% ± 1.6% and 0.5% ± 2.0% for group 1, 2, and 3, respectively, supplying our local confidence limit of 5.9%, 3.8% and 4.4%.
Conclusions: The PTW seven29/Octavius system allows a fast and accurate dosimetric procedure for VMAT pre-treatment verification, benefiting from all the advantages of ionization chamber absolute dosimetry. Despite the increased complexity in VMAT treatments, our local confidence limits were comparable to those of AAPM TG 119.

EP-1177

Designing, coding and implementing a software solution for daily output QA using an Electronic Portal Imaging Device

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Purpose/Objective: In the field of radiotherapy (RT) vast resources are being used on quality assurance (QA) to ensure the most precise treatment delivery. One important parameter to control and monitor is the dosimetric output from the linear accelerator. In recent years at this institute, this has been done by weekly output measurements with an ion chamber in a Perspex phantom. These measurements have been supplemented by daily output measurements using LINACHECK from PTW. However, modern linear accelerators allows for such measurements using the onboard Electronic Portal Imaging Device (EPID). The purpose of this study has been to design, code and implement a software solution for measuring and evaluating the daily output on the Varian iX and Truebeam accelerators using the EPID.
Materials and Methods: Daily warm-up and output measurement test patients were created for each accelerator. These consisted of four fields: two warm-up fields (25 x 25 cm^2, 400 MU, 6 and 15 MV) and two output measurement fields (25 x 25 cm^2, 100 MU, 6 and 15 MV) with the EPID positioned at SID = 100 cm and the measurements carried out by integrating dose over time. To collect reference data and allow for dosimetrically equivalent measurements, the output of all accelerators was measured and adjusted in water to within ± 0.3 % of reference values. Afterwards the integrated image mode of the EPID was calibrated for the clinical used D/R, followed by a dosimetric calibration using a 10x10 cm^2 field and 100 MU. Reference data was then collected using the test patients. All data was exported from the TPS as DICOM files. An algorithm for sorting measurements, calculating output, beam quality, symmetry and plotting in- and cross-line profiles was created using MATLAB. For easy accessibility and quick handling a graphical user interface (GUI) was also coded using the MATLAB GUI editor. Finally the algorithm and GUI were compiled to an executable, allowing the software to run independently of a MATLAB installation using the MATLAB Compiler Runtime (MCR). Several versions of the software was designed, compiled and deployed each targeting a specific personal group with different requirements. All measurements and results were saved to MATLAB data files for storage and easy accessibility.
Results: A lot of energy was used in the design phase of this project which clearly paid out in implementation and evaluation phase, where only minor issues related to the software arose, being primarily coding errors related to e.g. saving data. As a result of this several new versions with error corrections or minor functionality tweaks were deployed over the first months of implementation.
Conclusions: Using MATLAB for creating software to interact with data measured using the EPID exported via DICOM has proven itself possible, easy and reliable. Making in-house software gives the benefits of a highly customizable system alongside complete knowledge and control over algorithms and data handling.

EP-1178

Dosimetric verification of TPS, in vivo dosimetry and its clinical implementation

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Purpose/Objective: Verification of the calculated and delivered dose trough independent verification of treatment planning system (TPS) and in vivo dosimetry are important part of the overall radiotherapy quality assurance (QA). The verification of TPS was done according to IAEA recommendations and put an emphasis on dosimetry part of the treatment planning and delivery processes. In vivo dosimetry was implemented as quality assurance procedure for patient treatment verification.
Materials and Methods: Verification of TPS was done with anthropomorphic phantom which was later also used for in vivo measurements prior to patient measurements. Set of clinical test cases suggested by the IAEA, covering a range of typical clinical radiation techniques found in 3D conformal radiotherapy treatment (3D CRT) was used both for TPS and in vivo dosimetry verification. The doses were measured with ion chamber and semiconductor diodes, and compared to doses calculated in TPS for interest points for test cases and points in build up for entrance in vivo readings. Consequently, set of breast patients were checked by in vivo during their regular treatments. For patient treatment verification, tangential half fields were used and in vivo diodes were placed off axis, under large gantry angles, with different wedge types and angles.
Results: The measurements were conducted for 6 MV beam energy and advanced calculation algorithm. The differences between the measured and calculated doses for all test cases were within the tolerance level. The differences of in vivo phantom measurements and TPS calculation varied depending on the test type: 0.5% for open field case to 5.3% for enhanced dynamic wedge (EDW) test case. In vivo measurements conducted for breast patients showed difference of not more than 5% in comparison with values calculated by TPS.
Conclusions: After verification of TPS calculation, dose calibration and correction factors for semiconductor diodes were checked and prediction for in vivo doses in TPS was verified. The errors of 5 % magnitude are common in clinics worldwide and clinical implementation of in vivo dosimetry in our clinic has given confidence that patients are being treated with prescribed dose. This was opportunity to systematically review the uncertainties involved in treatment planning and dose delivery processes leading to more accurate patient treatment.
Acknowledgement: The work has been supported by IAEA through the national SRB6006 and regional RER 6023 technical cooperation project.

EP-1179

What the gamma? The correlation between QA and clinical risk estimates for prostate RapidArc plans

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Purpose/Objective: We investigate how QA criteria relate to sensitivity end specificity for increased normal tissue toxicity risk and risk of decreased tumour control in rotational therapy for prostate cancer.
Materials and Methods: QA analysis for 8 clinical plans and 160 plans with deliberately introduced errors was carried out using ten sets of QA criteria. The tumour control probability (TCP), and risk of rectal bleeding (NTCP_rectum), were calculated. An unacceptable plan was defined as a plan where TCP decreased by more than 2%, or the NTCP increased by more than 50%, as compared with the clinical plan. We chose the 50% NTCP threshold as the rectum was in the low dose region. The sensitivity and specificity for detecting unacceptable plans and their sum (S+S) were determined for each QA criteria set. The diagnostic quality of the QA criteria was also assessed by receiver-operator characteristics curves. For dose difference (DD) = 3 % and distance to agreement (DTA) = 3 mm; the required percentage of gamma smaller than 1 for acceptance (A) was scanned and the value of A which maximised S+S was determined. In an iterative process TCP and TNCP respectively were varied to find the values which corresponded to DD=3%, DTA =3 mm and A = 95 %.
Results: A set of DD = 3 %; DTA = 3 mm and A = 95 % corresponds to ensuring that TCP is > 99 %; and NTCP < 160%; of the clinical values. For DD = 3 %; DTA = 3 mm, S+S was maximised for A = 95 %. We could not identify a single set of QA parameters that was significantly better than the others. However, three of the criteria had a significantly lower area under the ROC curve than the best parameter sets.
Conclusions: A method for relating clinical risk estimates to QA parameters has been demonstrated. This method can be used to determine A for given DD and DTA values once the relative weights of sensitivity and specificity have been chosen by the user. It can also be used to determine which values of ΔTCP and ΔNTCP correspond to the chosen QA criteria set.

EP-1180

Dosimetric accuracy assessment of a treatment plan verification system for scanned proton beam radiotherapy

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Purpose/Objective: To assess the accuracy of a three-dimensional dose verification technique for patient-specific Quality Assurance (QA) in active scanning proton therapy. Critical cases of major deviations between treatment planning system (TPS) calculated and measured data points are further investigated with Monte Carlo (MC) simulations.
Materials and Methods: Treatment plan verification is performed in a water phantom with the simultaneous use of twelve small-volume ionization chambers (one data set), aligned in four rows in a way that none of them perturbs the other ones. The acceptance threshold is set at 5% for both mean deviation between measured and calculated doses and one standard deviation, over twelve measurement points. Results of 180 data sets, obtained along one year of clinical activity at the Italian National Center for Oncological Hadron Therapy (CNAO), were analyzed.Data were organized based on tumor site (skull versus sacrum) and TPS optimization technique (single field uniform dose SFUD versus intensity modulated particle therapy IMPT). A warning level was defined for data sets showing more than 30% of single point absolute deviations higher than 5% and needing further investigation. A MC tool for plan verification in water was implemented to evaluate the impact of dose calculation, dose delivery and measurement set-up uncertainties on the nine cases resulting out of the warning level.
Results: All patient-specific quality checks resulted within the acceptance threshold. Mean deviation between TPS dose calculation and measurement was less than ±3% in 86%of the cases. For targets located in the skull region an average higher deviation was found, compared to the sacrum region, due to more complex dose patterns involved. In addition, the use of a less robust optimization technique, such as IMPT compared to SFUD, produced much more scattered results and higher single point variation. When all sources of uncertainty were accounted for with the MC tool, all the simulated cases showed even higher level of agreement, with mean absolute deviation ≤ 2% (maximum absolute deviation< 5%).
Conclusions: Along this first year of clinical activity, the results of all patient-specific QA checks performed using ICs in a 3D configuration were found within the acceptance threshold. The use of a MC-based tool to investigate potential causes of major deviations should be further explored, particularly for more complex IMPT plans.

EP-1181

Optimization of VMAT patient specific QA using ImatriXX 2-D array system and ionometric point dose measurements

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Purpose/Objective: This study was performed to examine the effect of various factors on the optimization of volumetric modulated arc therapy (VMAT) patient specific quality assurance (QA).
Materials and Methods: Plans were created in eclipse treatment planning system (TPS) and measurements were performed in Varian Clinac-iX linear accelerator. Fifteen VMAT Plans were compared on the basis of type of delivery, number of arcs, complexity (treatment site), number of target volumes, and inclusion/exclusion of couch in the plans. For the same cases seven field intensity modulated radiotherapy (IMRT) plans were also created to compare QA results. Planar dose measurements were performed using ImatriXX 2-D array system of IBA dosimetry. Percentage of pixels passed the 3%-3 mm gamma criterion (% dose difference and distance to agreement-DTA) was taken for the comparison. Point dose measurements were also performed and the percentage deviation of the calculated doses versus measured doses was compared. Student'st-test was performed for the statistical analysis of the QA results.
Results: IMRT plans showed better QA results as compared to double-arc plans for head & neck site with more than one target volume (99.6% vs. 97.91% for the mean percentage of pixels passing the set